ORIGINAL

Squire, Sanders & Dempsey
L.L.P.
Counsellors at Law
1201 Pennsylvania Avenue, N.W.
P.O. Box 407
Washington, D.C. 20044-0407

Telephone (202) 626-6600
Cable Squire DC
Telecopier (202) 626-6780

Direct Dial Number
626-6600

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

February 16, 1999

Hon. William E. Kennard
Chairman, Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

EX PARTE OR LATE FILED

Re: *Ex Parte* Presentation of The Boeing Company
ET Docket No. 98-206,
RM-9147
RM-9245

Dear Chairman Kennard:

The Boeing Company ("Boeing") is an applicant to operate a non-geostationary orbit fixed-satellite service ("NGSO FSS") system in the Ku-band.[1] Boeing's NGSO FSS network will provide a host of new and innovative telecommunications services to consumers on a global basis. Boeing's system could bring substantial benefits to the American public and provide a significant opportunity for United States industry to export broadband satellite communications services.

In support of its application, Boeing has worked extensively with the United States government and international regulatory community to develop interference limits that will enable NGSO FSS networks to operate on a shared basis in the Ku-band with geostationary ("GSO") satellite and terrestrial fixed microwave networks.

The United States government has provided critical assistance to Boeing's spectrum sharing efforts. Working with the International Telecommunication Union, Radiocommunications Sector ("ITU-R"), the United States negotiated and endorsed a spectrum sharing compromise for the Ku-band that will enable Boeing and other companies to introduce a new generation of broadband satellite networks capable of serving consumers in all regions of the world.[2]

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[1] *See* Application for Authority to Launch and Operate a Non-Geostationary Medium Earth Orbit Satellite System in the Fixed Satellite Service, File No. SAT-LOA-19990108-00006 (Jan. 8, 1999).

[2] *See* International Telecommunication Union, Conference Preparatory Meeting, *CPM Report on Technical, Operational and Regulatory/Procedural Matters to be Considered by the 2000 World Radiocommunication Conference*, Radiocommunication Sector, Ch. 3 (Geneva, 1999).

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In conflict with these international efforts, Northpoint Technology, Ltd. ("Northpoint") petitioned the Commission for authorization to use a significant portion of the Ku-band for a one-way, point-to-multipoint television distribution system.[3] Northpoint chose not to participate in the international spectrum sharing studies. Instead, Northpoint has attempted to justify its proposal using inappropriate interference methodologies and criteria. Northpoint's methodologies are internally inconsistent, using one criterion to calculate interference into NGSO FSS systems, while using a far more protective criterion to calculate interference into its own system.

As Boeing demonstrates in the accompanying technical analysis, Boeing's NGSO FSS network cannot share spectrum with Northpoint and will be unable to mitigate interference from Northpoint transmitters. Boeing's analysis is consistent with demonstrations by other NGSO FSS applicants and direct broadcast satellite ("DBS") system operators, documenting that Northpoint's proposed system would cause unacceptable interference into existing and future satellite services.

A decision to allocate spectrum in the Ku-band for Northpoint would jeopardize the substantial export and employment opportunities that NGSO FSS networks will provide to U.S. industry and would prevent the introduction of new communication services to the public. The international community is also likely to view an allocation for Northpoint as an unjustifiable repudiation of the spectrum sharing compromise that the United States agreed to support in the ITU-R process.

Boeing urges the Commission to advance the interests of U.S. consumers and U.S. industry by preserving the Ku-band for the rapidly growing and U.S. dominated satellite communications industry. Any attempt to accommodate Northpoint should be done by identifying licensing opportunities for the company within the more than three gigahertz ("GHz") of spectrum previously made available by the Commission for terrestrial point-to-multipoint and wireless communication services.

The Northpoint Exclusion Zones

As Northpoint has acknowledged throughout this proceeding, Northpoint's proposed service would create exclusion zones around each Northpoint transmitter,[4] within which NGSO FSS receivers would suffer unacceptable interference. Northpoint concedes that these exclusion zones would result in the "loss of a significant portion of the service area" for Skybridge, Hughes Net, and Hughes Link NGSO FSS systems.[5] Northpoint claims, however,

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[3] *See* Northpoint Petition for Rulemaking, RM-9245 (Mar. 6, 1998).

[4] *See Comments of Northpoint Technology, Ltd.*, ET Docket No. 98-206, at 28 & Technical Annex at 32 (Mar. 2, 1999) ("*Northpoint Comments*").

[5] *Id.*

that the Boeing NGSO FSS system would suffer only modest exclusion zones of about 200 meters around each Northpoint transmitter.[6]

Northpoint uses inappropriate interference methodologies and a fraction of its proposed operating power to calculate the size of the exclusion zones. Correcting for the first error, Boeing's NGSO FSS network would suffer exclusion zones of three kilometers (7.07 square kilometers) around each transmitter if Northpoint operates at its tested power. This is an area 544 times larger than the 0.13 square kilometer area estimated by Northpoint. It is also about twice as large as Northpoint's estimated exclusion zone for the Hughes Link system, which Northpoint itself described as a "loss of a significant portion" of its service area.[7]

Correcting for Northpoint's second error, if Northpoint operates its transmitters at full power, rather than the tested power, Boeing's system would suffer exclusion zones that would extend 129 kilometers (13,070 square kilometers) from each transmitter. Northpoint has admitted that it will use higher power levels "in some circumstances."[8]

The Commission cannot expect Boeing to construct a nearly six billion dollar satellite system based on vague assurances by Northpoint that it will not boost power sufficiently to shut down Boeing's operations except "in some circumstances." Regardless, Boeing believes that Northpoint will be forced to use higher power levels on most of its transmitters on a regular basis if it wants to overcome the detrimental impacts of rain and provide consumers with the same quality and reliability of uninterrupted service offered by competitors.

Northpoint has urged the Commission to disregard the expansive exclusion zones that will be produced by its system, arguing that interference mitigation techniques are available that could be used by NGSO FSS networks. Unfortunately, most of Northpoint's mitigation techniques simply will not work. Northpoint underestimates the extent of the interference and misunderstands the mechanics of NGSO networks. Northpoint's remaining interference mitigation techniques would be prohibitively expensive, or could reduce the transmission capacity of Boeing's NGSO network sufficiently to compromise its viability.

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[6] *See id.*

[7] *Id.* The exclusion zone calculated by Northpoint for the Hughes Link system is 3.72 km^2, almost half the 7.07 km^2 exclusion zone that will be experienced by Boeing. *See id.*

[8] Letter to Donald Abelson, Chief, International Bureau, from Antoinette Cook Bush, Counsel for Northpoint Technology, Ltd., at 4 (Jan. 20, 2000) ("*January 20th Letter*").

Satellite Diversity Will Not Reduce Interference From Northpoint

Northpoint argues that NGSO FSS networks can use "satellite diversity" to mitigate interference resulting from Northpoint's transmitters.[9] Satellite diversity is the technique used by NGSO FSS systems to avoid causing unacceptable interference into GSO networks and other NGSO systems. Northpoint is presumably suggesting that whenever Northpoint's transmissions interfere with the link between a NGSO satellite and a NGSO consumer receiver, the consumer receiver should switch to a different NGSO satellite.

Unfortunately, two factors make it impossible for Boeing to use satellite diversity to prevent interference from Northpoint's system. First, the design of Boeing's NGSO FSS system does not permit Boeing to provide simultaneous beams from more than one satellite to the same location.[10] To do so would greatly increase Boeing's power levels to the ground and may exceed the interference limits proposed by the ITU-R and FCC to protect GSO receivers. Furthermore, providing multiple satellite coverage over the United States would greatly increase the number of spacecraft that would be needed in Boeing's constellation. This would substantially increase the expense of its system and the cost of its service to the public.

Second, even if Boeing's network could employ satellite diversity in this way, it would do nothing to mitigate interference from Northpoint. Interference from the Northpoint system comes into the far sidelobe of Boeing's consumer receivers, rather than directly into the main beam. As a result, switching the consumer receiver to look at a different Boeing satellite will not change the antenna gain in the direction of the interference source. No matter which way the Boeing earth station antenna is pointed, the interference level from Northpoint will be approximately the same or greater. As a result, satellite diversity could not be used to successfully mitigate interference from the Northpoint system.

Natural Shielding Will Not Appreciably Aid Boeing's Network

Northpoint also suggested that natural shielding may be able to protect some NGSO FSS receivers, noting that many DBS receivers are mounted on the south side of structures that provide them with natural shielding to the north.[11] Of course, DBS receivers are pointed continually in a single direction – south towards the GSO arc. In contrast, NGSO FSS earth station receivers must be able to see in all directions in order to communicate with NGSO

[9] *See, e.g., id.* at 2; *See, e.g.,* Letter to Ms. Magalie Roman Salas, Secretary, FCC, from Antoinette Cook Bush, Counsel to Northpoint, Technical Analysis at 12-13 (Jan. 6, 2000) ("*January 6th Letter*"); *Northpoint Comments*, Technical Annex at 35.

[10] While Boeing's NGSO beams will overlap at the edges to accommodate satellite handoffs, the overlap would be entirely inadequate to permit a Boeing receiver in the middle of a satellite beam (which will be approximately 1800 kilometers in diameter) to switch over to a beam from a different satellite.

[11] *See January 6th Letter*, Technical Annex at 12.

satellites down to a 30° elevation angle. Furthermore, because Boeing shuts down its satellites within a 15° exclusion zone around the GSO arc, consumer receivers in the United States will often be pointed toward the north to communicate with NGSO satellites located at latitudes north of the receivers' location.

As a result, it is highly unlikely that natural shielding will be available to block interference from Northpoint's transmitters, while still allowing visibility of Boeing's NGSO satellites. Therefore, shielding to mitigate interference from the Northpoint transmitter would require the construction of an artificial wall between the Northpoint transmitter and the Boeing receiver. As explained below, erecting such shielding would be extremely impractical and prohibitively expensive.

Artificial Shielding Would be Prohibitively Expensive

Northpoint has claimed that artificial shielding could be used to protect NGSO FSS consumer receivers.[12] In order to shield a Boeing receiver, a wall would have to be constructed between the receiver and Northpoint's transmitter that is tall enough to block interference from Northpoint, but does not prevent communication with Boeing satellites down to a 30° elevation angle. In addition, the wall must be far enough away from Boeing's receiver (which will include both a transmitter and receiver) to prevent distortion from signals reflected off the wall.

Unfortunately, it will often be impossible to achieve these requirements. For example, a wall could not be constructed that would be high enough to protect a Boeing receiver that is within about 350 meters of an elevated Northpoint transmitter because the wall would also block reception to Boeing satellites at some elevation angles. Even if it was possible to construct such a wall, however, it would be entirely impractical.

Whenever a Boeing receiver is within one kilometer of a Northpoint transmitter, the shielding wall would have to be unreasonably tall to effectively block Northpoint's signal. For example, a wall at least three to six meters in height would be need to protect a Boeing BDS[13] receiver located 500 meters from a Northpoint transmitter on a 150 meter tower, and a wall at least four to eight meters in height would be needed for a receiver located 400 meters from a Northpoint transmitter. Any closer to the transmitter and the wall's height increases geometrically, exceeding ten meters in height just under 400 meters from the Northpoint transmitter location.

Obviously, it would be prohibitively expensive to construct shielding walls that are sufficiently tall to protect Boeing consumer receivers. Furthermore, it would be unreasonable to expect a Boeing customer (or landowners adjacent to the customer) to accept the

[12] *See id.*, Technical Annex at 10.

[13] BDS stands for Boeing's Backhaul Data Service.

construction of such a wall as a prerequisite to the receipt of Boeing's service. Therefore, Northpoint's artificial shielding is unworkable as a solution and must be discarded.

Frequency Diversity is Also Inadequate to Mitigate Northpoint Interference

Another mitigation technique proposed by Northpoint is "frequency diversity," which appears strikingly similar to band segmentation. Under Northpoint's proposal, NGSO FSS networks would be barred from using Northpoint's desired spectrum (the 12.2-12.7 GHz band) to serve consumers within the exclusion zone around each Northpoint transmitter.[14] Instead, NGSO FSS networks would be limited to the 11.7-12.2 GHz band within the exclusion zones and would be able to use the entire 11.7-12.7 GHz band outside the exclusion zones.

Northpoint's proposal is premised on several significant misunderstandings about the mechanics of NGSO FSS networks such as Boeing's. Boeing is employing a medium earth orbit ("MEO") constellation to lower costs for consumers and reduce interference into GSO networks. The beams from Boeing's MEO satellites are about 1800 kilometers in diameter, far too large to differentiate between customers inside and outside Northpoint exclusion zones. Each satellite beam will include two 166.6 MHz channels, which will be used on a shared basis by all customers using a code division multiple access ("CDMA") scheme. As a result, customers will be unable to use discrete band segments to avoid interference from Northpoint.

Northpoint also suggests that Boeing segregate the two 166.6 MHz channels in each satellite beam, operating one channel in the 11.7-12.2 GHz band, where Northpoint will not produce interference, and operating the other channel within the 12.2-12.7 GHz band, co-frequency with Northpoint.[15] Northpoint argues that Boeing could use the lower channel to serve customers inside the exclusion zones and use both channels to serve customers outside the exclusion zones.

Northpoint's proposal might seem appropriate for a satellite system designed to carry traditional point-to-point telephone services, where each call originates at one point and terminates at another discrete location. Unfortunately, very few of Boeing's customers are expected to use Boeing's satellite system in this manner. Instead, most transmissions will involve point-to-multipoint communications – such as a corporation or government agency transmitting the same information to numerous recipients, or an Internet service provider using smart push technologies to continually update an Internet page being viewed simultaneously by thousands of customers.

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[14] *See January 20th Letter* at 2; January *6th Letter*, Technical Annex at 13; *Northpoint Comments*, Exhibit 1 at 34.

[15] *See January 20th Letter* at 2 n.3.

Because of the point-to-multipoint nature of Boeing's services, any spectrum mitigation technique that forces Boeing to isolate many of its consumer receivers to a single 166.6 MHz channel would significant reduce the effective capacity of Boeing's system. Boeing would be forced to accommodate all point-to-multipoint communications in the lower 166.6 MHz channel assignment to ensure that intended recipients inside Northpoint exclusion zones successfully receive transmissions. Since the vast majority of Boeing's services will be point-to-multipoint in nature, Boeing's network would be left with inadequate spectrum capacity that is unencumbered by Northpoint interference, compromising the financial viability of Boeing's global network.

Band Segmentation Would Undermine the Viability of Boeing's Network

As discussed in the previous sections, Northpoint's proposed service would cause unacceptable interference into Boeing's NGSO FSS network, interference that could not be cured through mitigation. Apparently aware of this, Northpoint has proposed a final option to advance its service – band segmentation.[16] Boeing urges the Commission to reject this option as incompatible with the successful launch of universally available satellite communication services and in conflict with the spectrum sharing agreement on NGSO FSS networks that the United States agreed to support in the international ITU-R process.

In weighing the option of band segmentation, a principal consideration for the Commission should be the impact that will result on prospective spectrum users and consumers of new communication services. Boeing's proposal to construct and launch a global satellite network involves a significant level of investment risk. Boeing's 20 satellite constellation will cost nearly six billion dollars, most of which must be paid up front as fixed cost.

In contrast, almost all of the revenue generating potential of Boeing's network is variable – dependent directly on the amount of throughput, or spectrum capacity that is available for Boeing's use. As is well known, the critical variable for a modern network, whether terrestrial or satellite based, is the forward throughput capacity of the system. For this reason alone, Boeing is extremely concerned about suggestions that it should sacrifice a portion of its forward service link capability.

Boeing must maximize its revenues in the United States in order to minimize the investment risk of building its NGSO system to acceptable levels. Any proposal that reduces the spectrum available for Boeing's forward service links will result in unacceptable risk that will undoubtedly affect Boeing's decision to field an NGSO network. In light of these facts, Boeing urges the Commission to reject band segmentation as an unproductive option to resolve the conflicts in this proceeding.

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[16] *See January 6th Letter* at 2; Letter to Ms. Magalie Roman Salas, Secretary, Federal Communications Commission, from Brian Weimer, Counsel for Northpoint Technology, Ltd., at unnumbered p. 6 (Dec. 1, 1999).

Northpoint Should Operate Within Previously Allocated for Terrestrial Spectrum

Throughout this proceeding, Boeing has urged the Commission to further the interests of U.S. consumers and U.S. industry by preserving the Ku-band for the rapidly growing broadband satellite communications industry. Accordingly, any efforts to accommodate Northpoint's terrestrial point-to-multipoint service should be done using existing licensing opportunities in portions of the more than three gigahertz of spectrum that the Commission has previously made available for point-to-multipoint and wireless services.

For example, Northpoint could seek licenses in the Local Multipoint Distribution Service ("LMDS"), the Digital Electronic Messaging Service ("DEMS") the Multipoint/Multichannel Distribution Service ("MMDS"), or the satellite master antenna television ("SMATV") service. Such services permit two-way communications, a significant advantage over Northpoint's proposed one-way service. Furthermore, according to a recent FCC report, MMDS subscribership has fallen 17.9% in the last year, indicating that MMDS licenses may be available at affordable rates.[17] Northpoint could also seek spectrum in the Wireless Communication Service ("WCS"), the General Wireless Communications Service ("GWCS"), or the recently created 700 MHz and 39 GHz wireless bands, the last two of which are scheduled to be auctioned by the Commission to new licensees shortly.

In any event, the Commission should not harm this country's rapidly growing broadband satellite communication industry by creating a new terrestrial spectrum allocation in a frequency band that was long since cleared by the Commission for satellite use. Instead, the Commission should advance the interests of U.S. industry by preserving the 12.2-12.7 GHz band for satellite communications services. The Commission should also further the interests of U.S. consumers by authorizing the launch of a new generation of broadband satellite communication systems using NGSO constellations in the Ku-band.

Respectfully submitted,

David A. Nall
Bruce A. Olcott
Counsel for The Boeing Company

Cc: R. Craig Holman,
Counsel, The Boeing Company

[17] *See Annual Assessment of the Status of Competition in Markets for the Delivery of Video Programming*, Sixth Annual Report, FCC 99-418, ¶ 15 (Jan. 14, 1999).

The Boeing Company

Analysis of Interference Characteristics of

Northpoint Technology, Ltd.

February 16, 2000

Northpoint Interference Analysis

1 Introduction:

Northpoint is proposing a terrestrial point-to-multipoint television distribution system that is seeking to operate in the 12.2 to 12.7 GHz band, co-frequency with the Broadcast Satellite Service (BSS) and the non-geostationary orbit (NGSO) Fixed Satellite Service (FSS). The purpose of this document is to evaluate the interference analysis provided by Northpoint with respect to the Boeing NGSO FSS system and to document a valid analysis based on correct assumptions. Additionally, this document will evaluate the usefulness of the interference mitigation strategies proposed by Northpoint.

The information on the Northpoint system characteristics is extracted from the Technical Annex to the NPRM comments made by Northpoint.[1] The characteristics of the Boeing NGSO FSS system are contained in its application to the FCC.[2]

2 Interference Criteria:

In its "Technical Annex to Comments of Northpoint Technology" filing on the Commission's Notice of Proposed Rulemaking ("NPRM"), filed March 2, 1999, Northpoint proposed the interference criteria shown in Table 1 for sharing with NGSO systems.[3]

Table 1: Northpoint Proposed Interference Criteria for NGSO FSS Receivers

I/N Level	Percent of Time
0 dB	0.01
-12.2	20

Table 1 shows what Northpoint proposes as the interference criteria for interference from Northpoint into NGSO FSS systems. The interference criteria is incomplete in that it does not define what interference the interference level is for periods of time greater that 20 %. Additionally, Northpoint uses an interference-to-noise ("I/N") ratio of 0 dB to define unacceptable short term interference into Boeing's NGSO network.[4] Given the characteristics of the Boeing NGSO FSS system, these interference criteria would not seem to be appropriate as will be explained later. Northpoint apparently understands that its definition of interference is inadequate. In order to seek protection for its own system,

[1] *See Comments of Northpoint Technology, Ltd.*, ET Docket No. 98-206, Technical Annex (Mar. 2, 1999) ("*Northpoint Technical Annex*").

[2] *See* Application for Authority to Launch and Operate a Non-Geostationary Medium Earth Orbit Satellite System in the Fixed Satellite Service, File No. SAT-LOA-19990108-00006 (Jan. 8, 1999).

[3] *See Northpoint Technical Annex* at 31.

[4] *See, e.g.,* Letter to Ms. Magalie Roman Salas, Secretary, FCC, from Antoinette Cook Bush, Counsel to Northpoint, Exhibit A, Technical Analysis at 10 (Jan. 6, 2000) ("*January 6th Letter*").

Northpoint's analysis uses an interference limit that is ten times greater than the interference limit it suggests to protect NGSO FSS networks.

More appropriate interference criteria can be found in ITU-R Recommendation S.1323, which was developed by international working groups, with substantial participation by the United States government and domestic industry. The recommendation indicates that each spectrum user should limit its interference into co-frequency systems sufficiently so that it is responsible for no more than 10% of the "unavailability" (or signal interruption) of other systems.

The interference criteria was developed primarily for the case of interference between NGSO FSS systems and GSO FSS systems, where the interference level changes due to the relative motion between the two systems. The S.1323 criteria is applicable in the case of Northpoint's interference into a NGSO network because Northpoint's interference emanates from a fixed location, while NGSO earth station antennas are always in motion tracking NGSO satellites. In effect, Northpoint appears to the NGSO FSS earth station as the terrestrial equivalent of a GSO FSS system.

The first step in applying Recommendation S.1323 is to determine the "unavailability" of Boeing's system independent of Northpoint's proposed system. As with all Ku-band satellite systems, the major cause of unavailability for the Boeing system earth station receiver is outage due to rain. The attenuation due to rain is dependent on several factors, one of which is the elevation angle of the earth station antenna. With a NGSO satellite system, the earth station antenna is constantly changing its elevation angle as it tracks the NGSO satellites. In order to determine the overall unavailability due to rain, it must be calculated at each elevation angle, multiplied by the probability that the earth station antenna is at that elevation angle, and integrated over all elevation angles.

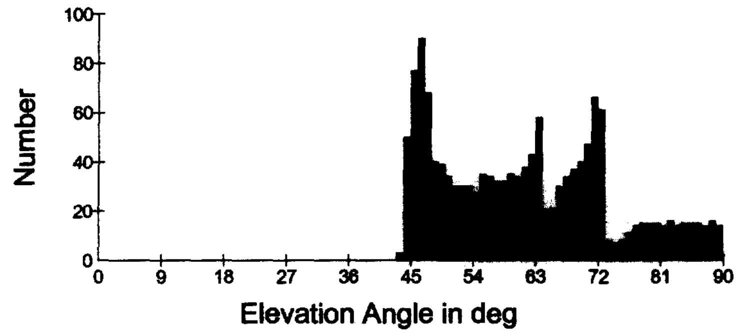
$$p_{rain}(\deg r) = \int_{elv} p_{rain}(\deg r \mid \theta) \bullet p(\theta) d\theta \qquad (1)$$

where degr is the signal degradation,
θ is the elevation angle, and
p() is the Probability Density Function (PDF) that the signal degradation due to rain will be at a given level.

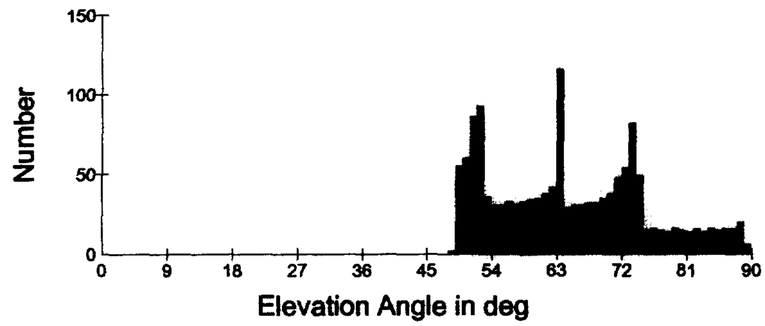
This calculation has been done for the Boeing system at a number of latitudes varying from 20° North latitude to 50° North latitude. Figure 1 shows plots of the probability distribution for the elevation of the earth station receive antennas in the Boeing system operating at different latitudes. The assumption is that the earth station is assigned to the highest elevation Boeing NGSO satellite in its view. This assumption is only valid for the Boeing NGSO system operating independently of other NGSO systems. In a case where the Boeing system shares spectrum with another NGSO system and uses satellite diversity to avoid interference into a second NGSO system, the probability distribution of elevation angles would shift to lower elevation angles. As the NGSO sharing schemes are still under discussion, no data is currently available on the elevation angle distribution in this sharing environment.

There are several additional factors other than elevation angle between the earth station and satellite that are used in determining the unavailability due to rain. These include the rain zone, latitude, altitude of earth station, and polarization. The Boeing system uses circular polarization and has been designed to have an unavailability of 0.1 % in rain zone K for an earth station at sea level. Rain zone K covers much of the East Coast and Midwest. The Western part of the U.S. has milder characteristics with rain zones B, D, and E. The southeast has increased rain with zones M and N. Boeing's analysis herein uses a nominal rain condition for the U.S. and not either of the extremes.

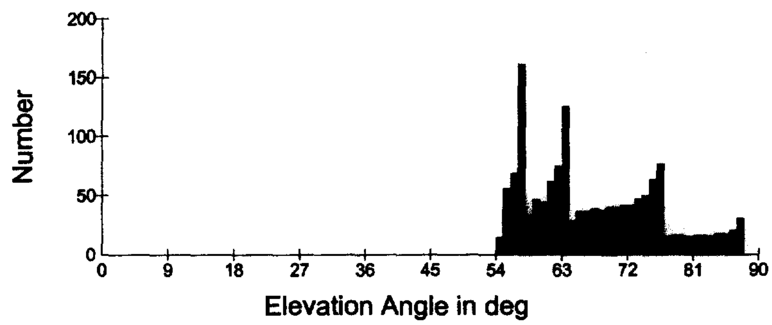
NGSO ES at 20 deg latitude



NGSO ES at 25 deg latitude



NGSO ES at 30 deg Latitude



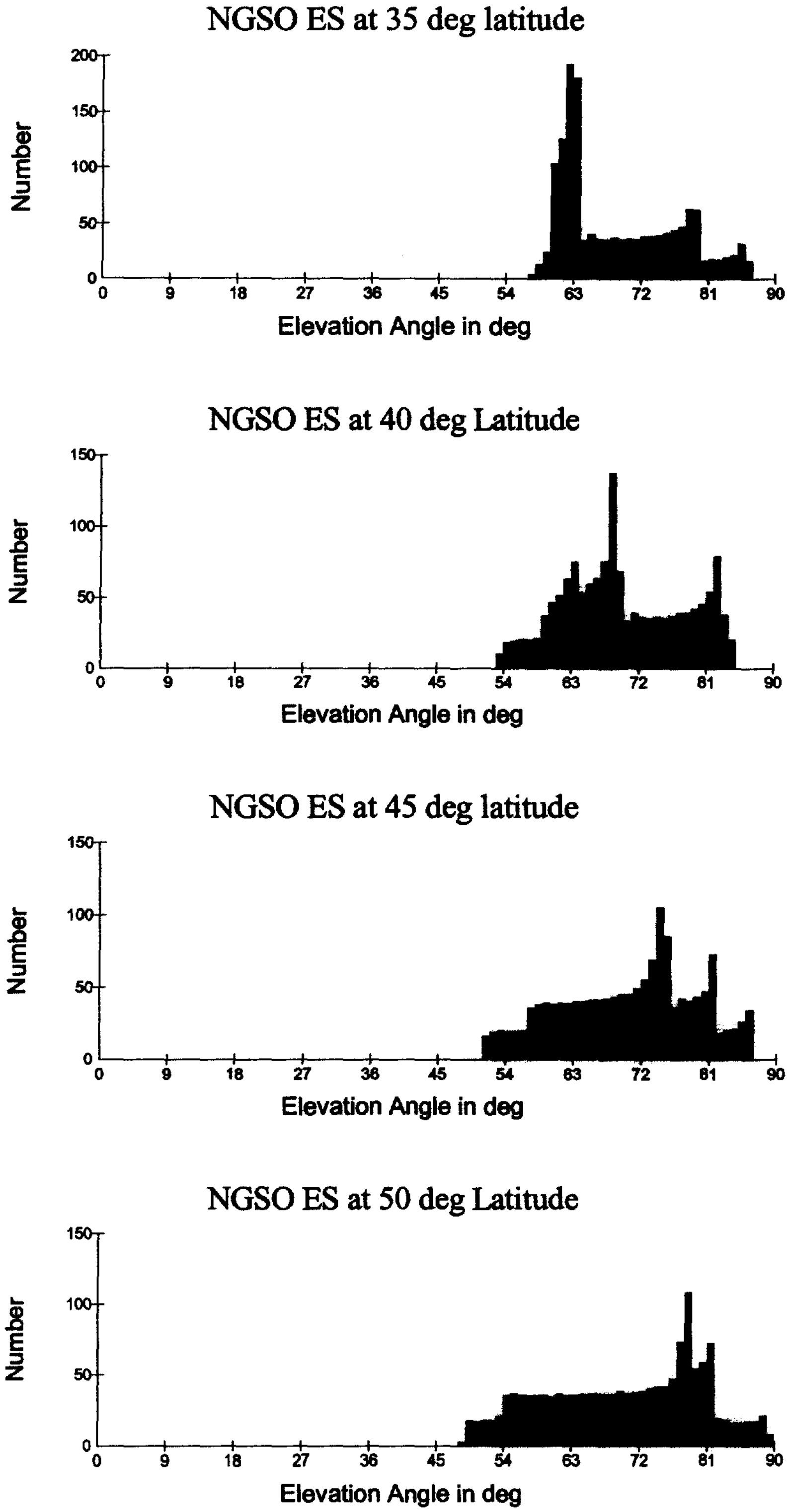


Figure 1: Elevation Angle Probability Distribution for Different Latitudes

Figure 2 shows plots of the Boeing system unavailability due to rain as a function of the degradation for latitudes of 35 and 40 degrees North latitude as computed using equation 1 above. It should be noted that to achieve 99.9 % availability, or 0.1 % unavailability, requires a system margin of 1.23 dB at 35° latitude and 1.13 dB at 40° latitude.

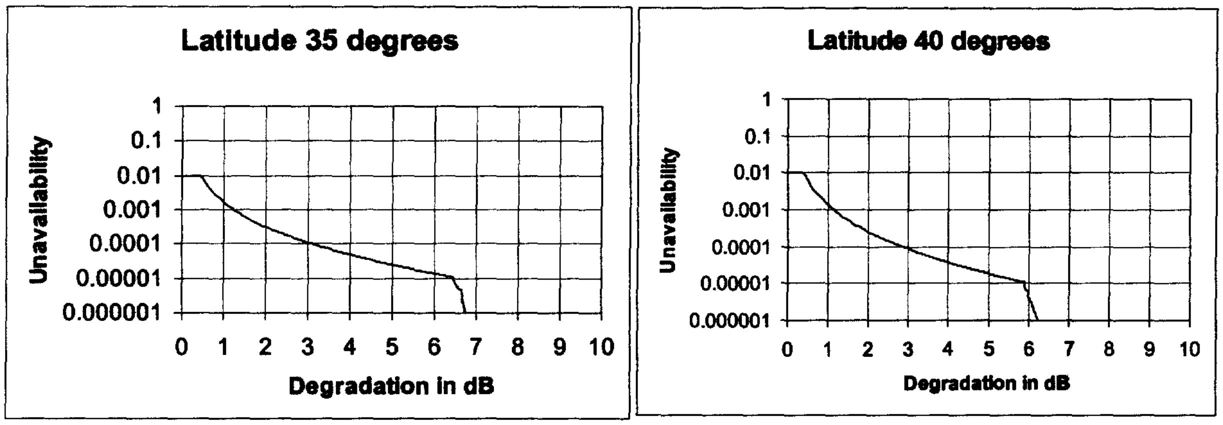


Figure 2: Unavailability Due to Rain

A 10 % increase in unavailability due to interference would increase the overall unavailability from 0.1 % to 0.11 %. Assuming that the interference is transmitted at a constant level, the increased interference would have the effect of shifting the curve in Figure 2 to the right slightly. This increase in unavailability would result from an increase in the C/N degradation of 0.05 dB at 35° latitude, or 0.046 dB at 40° elevation. While the interference is not necessarily constant, it is treated as an approximation to simplify the analysis. Additionally, section 3.2 shows that while the interference is not necessarily constant, a constant level can be treated as a lower bound and is a conservative approximation for Northpoint interference into the Boeing system in many conditions.

The resultant increased system degradation and increased unavailability occurs at an interference to noise density ratio, Io/No, of -19.4 dB at the 35° latitude and –19.7 at the 40° latitude.

In determining the separation distance between a Northpoint transmitter and a Boeing earth station receiver in the following analysis, an Io/No of –19.4 dB will be used. Again, this will allow more interference into the Boeing NGSO earth station receiver than the 10 % unavailability criteria. It should be noted at this point that the 10% increased unavailability criteria is an aggregate criteria that includes interference from all sources including other GSO and NGSO systems operating co-frequency. In this analysis, the entire 10 % increased unavailability limit was given to the Northpoint system.

3 Analysis:

Figure 3 shows the interference scenario that was analyzed. A single Northpoint transmit antenna is pointed south. The Boeing system receiver is directly south of the Northpoint transmitter. The analysis assumes line-of-sight communications from the Northpoint transmitter to the intended Northpoint receivers and the interfered with Boeing receiver.

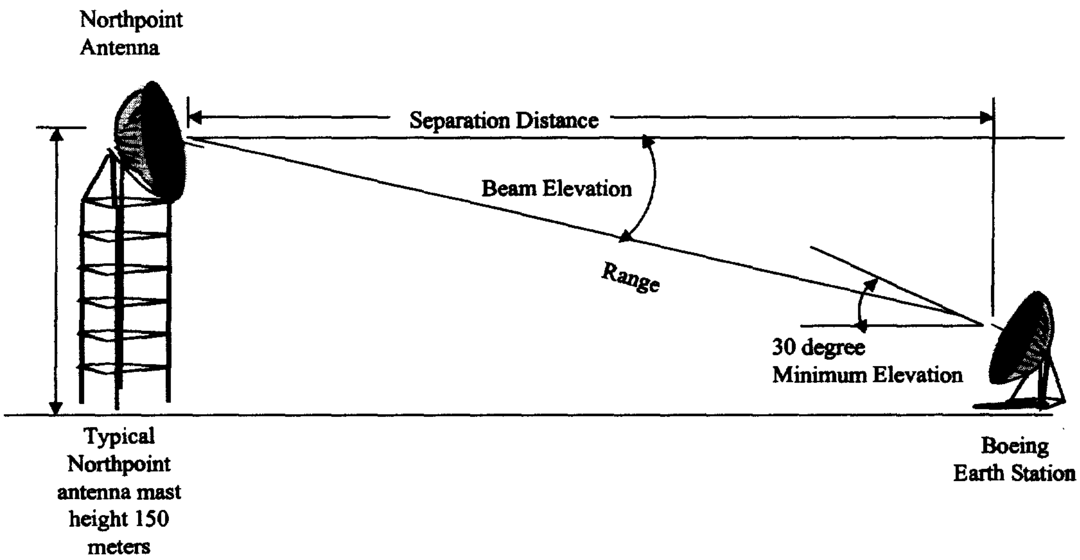


Figure 3: Northpoint Interference Geometry

3.1 Northpoint Transmit Characteristics:

The Northpoint transmit antenna gain in the direction of the Boeing receiver is 10 dB and the transmit EIRP used in this analysis is Northpoint's nominal tested value of –17.5 dBW.[5] It should be noted, however, that Northpoint has requested authorization to transmit at power levels of up to +15 dBW.[6] Operation at this higher power level would cause significantly more interference into Boeing receivers and would produce significantly larger exclusion zones where Boeing receivers would not be able to operate. When the nominal transmit EIRP is spread over a 24 MHz bandwidth a EIRP density of –91.3 dBW/Hz results.

3.2 Boeing Earth Station Receive Characteristics:

The reference antenna pattern used for the Boeing system receive antenna is ITU-R Recommendation S.[4/57]. This antenna pattern was developed for the situation where there is relative motion between the interfering source and victim systems. Therefore, it is applicable to the current interference study. Figure 4 is a plot of this reference pattern for the Boeing earth station receive antenna.

[5] *See id.* at 2, Table 1.

[6] *See Application of Broadwave Tampa, LLC for License to Provide a New Terrestrial Transport Service in the 12.2-12.7 GHz Band* (Engineering/Technical Parameters Exhibit) (Jan. 8, 1999) ("*Broadwave Applications*").

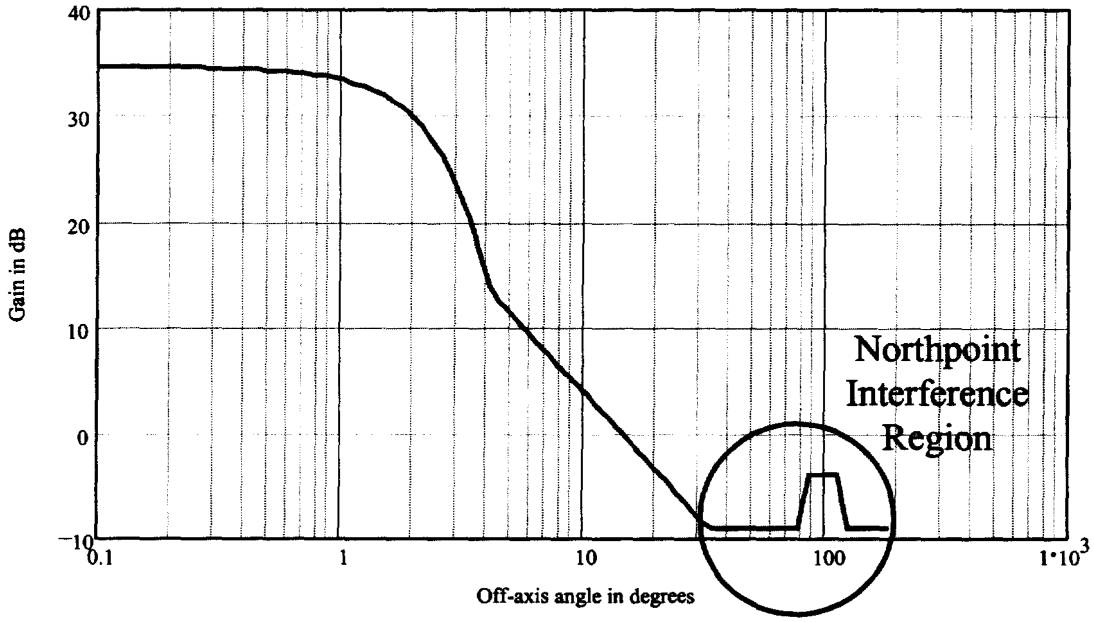


Figure 4: Boeing Earth Station Receive Antenna Reference Pattern

The Boeing system operates with a minimum elevation angle of 30 degrees. A simulation of the Boeing system operating alone shows that the actual elevation angle will be greater than 40 degrees most of the time. When one accounts for sharing with other NGSO systems using satellite diversity, however, the likelihood of the minimum elevation angles dropping down to 30 degrees increases significantly. Therefore, a minimum elevation angle of 30 degrees will be used in this analysis. Additionally, if one examines the reference antenna pattern of Figure 4, the antenna gain is a flat –9 dB at off-axis angles greater than about 33 degrees. (There is a 5 dB increase in the antenna gain from about 80 degrees to 120 degrees, which would increase the interference from the Northpoint system.) To simplify the interference analysis, it will be assumed that the Boeing receive antenna has a constant gain toward the Northpoint transmitter of –9 dB. It should be noted, however, that the gain could be 5 dB greater than this at higher elevation angles. Therefore, the present analysis will underestimate the interference due to the Northpoint system impinging on Boeing earth station receivers.

The clear sky noise temperature of the Boeing receiver is 230 degrees K, which gives a receiver thermal noise density of –205 dBW/Hz.

3.3 Interference Link Budget

Table 2 provides an interference link budget for the Northpoint system interfering into the Boeing system earth station receiver. The analysis calculates the free space path loss required for the Northpoint system to meet the interference criteria developed above, i.e. Io/No = -19.4 dB. From the required path loss, the necessary separation distance between the Northpoint transmitter and the Boeing earth station receiver is then calculated.

Table 2 Interference Link Budget		
Transmit EIRP	**-17.50**	**dBW**
Transmit Bandwidth	24.0	MHz
Transmit EIRP Density	-91.3	dBW/Hz
Receive antenna gain to Northpoint	-9.0	dB
Receive Noise Temperature	230.0	K
Receive Noise Density	-205.0	dBW/Hz
Io/No Required	-19.4	dB
Pathloss Required	124.1	dB
Frequency	12.5	GHz
Separation Required	**3.02**	**km**

The minimum separation distance required to meet the interference criteria is 3 km for the case of a single interfering Northpoint transmitter operating at a nominal transmit EIRP of –17.5 dBW. Figure 5 shows a plot of the service area of the Northpoint transmitter operating at its nominal transmit power. The plot also shows the exclusion zone that would be created, within which Boeing receivers would have interference above the interference limit.

In its March 2nd Technical Annex, Northpoint states "...loss of a significant portion of the service area is possible for the Skybridge, Hughes Net, and Hughes Link systems."[7] The exclusion zone for the Hughes Link system, as calculated by Northpoint, is 3.72 square kilometers ("km^2"). Using a minimum separation of 3.02 km results in an exclusion zone for the Boeing system of 7.07 km^2. Clearly, if by Northpoint's own contention that a 3.72 km exclusion zone causes "loss of a significant portion of the service area," then the larger exclusion zone area experience by Boeing would also be deemed significant by Northpoint.

[7] *See Northpoint Technical Annex* at 32, § 4.2

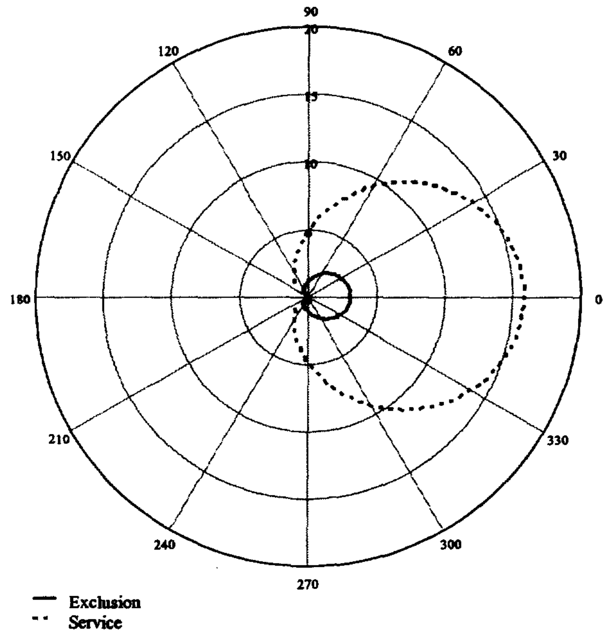


Figure 5: Northpoint Operating Region and Boeing System Exclusion Zone

Northpoint's application indicates that the Northpoint system will have the ability to increase its transmit power.[8] Northpoint has explained in ex parte communications that increased power would be used where terrain or customer density would require it.[9] In anticipating the potential interference into the Boeing NGSO FSS network, however, Boeing must assume that Northpoint may increase its transmitter power on a regular basis in every community where it operates. This is a major concern for Boeing. For example, if the Northpoint transmit EIRP is increased to the maximum power level of +15 dBW that is indicated in Northpoint's Broadwave affiliates' applications, the required separation distance between a Northpoint transmitter and Boeing earth station receiver grows to 129 km. This would effectively exclude Boeing's NGSO FSS network in any community where Northpoint operates.

It is Boeing's understanding that Northpoint plans to operate a number of transmitters in large metropolitan areas using repeaters at the same frequency. Boeing currently has no information on the density of repeating transmitters or their overlapping footprints. Lacking the detail plans for repeaters, Boeing has made some assumptions in a brief analysis.

As was stated earlier, the above analysis and determination of the size of the exclusion zone assumed line-of-sight conditions. In situations where terrain is a significant factor, such as Seattle and San Francisco, Northpoint will have to increase power or place its

[8] *See Broadwave Applications.*

[9] *See Northpoint Technical Annex* at 18.

repeater transmitters closer together than would be suggested by the nominal power analysis. Either of these options would have the effect of increasing the size of the exclusion zone relative to the service area. Increasing the Northpoint transmit power directly increases the size of the exclusion zone. Placing the Northpoint repeaters closer together will decrease the size of the service area, while increasing the percentage of the service area that is in the exclusion zone.

Northpoint also gives the nominal height of the transmit antenna as 150 meters above the average terrain level,[10] which is roughly equivalent to a 40 story building. It is unlikely that Northpoint would construct a tower of this size solely for its transmitter. Therefore, Northpoint would likely attempt to identify existing structures on which to mount transmit antennas. This would significantly constrain the locations for transmitters.

Furthermore, it also seems unlikely that land use regulations would permit Northpoint to construct 150 meter towers in many areas. The other choice would be to build lower towers, e.g. 30 meters, which would have more difficulties with terrain and blockage, once again potentially enlarging the exclusion zone relative to the service area. In this case, the Northpoint service area would be reduced and the exclusion zone would be a larger percentage of the service area.

Figure 6 shows a potential grid layout for the Northpoint repeater system. Again, this assumes that the terrain is essentially flat, with no terrain blockages. The grid is a regular hexagonal array with overlapping coverage, enabling the entire Northpoint service area to receive the minimum signal required for operation. Because an overlap is required to provide a minimum service level to Northpoint customers, the exclusion zone area is enlarged relative to the effective size of the service area. The Boeing receiver would also be receiving interference from multiple Northpoint transmitters, which would increase the size of each exclusion zone slightly. Uneven spacing will also produce signal overlap from multiple Northpoint receives, which could produce additional exclusion zones that are not directly adjacent to any single Northpoint transmitter.

As stated above, typical operation of the Northpoint system in the same frequency bands as used by the NGSO FSS systems will create exclusion zones where the NGSO FSS receivers will receive unacceptable interference from the Northpoint transmitters. For example, a 3 km diameter exclusion zones occurs for the Boeing system using Northpoint's lower power level of -17.5 dBW. This equates to an area of 7.07 km^2, which is 544 times larger than the 0.13 km^2 estimated by Northpoint.[11]

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[10] *See id.* at 2, Table 1.

[11] *See id.* at 32, Table 20.

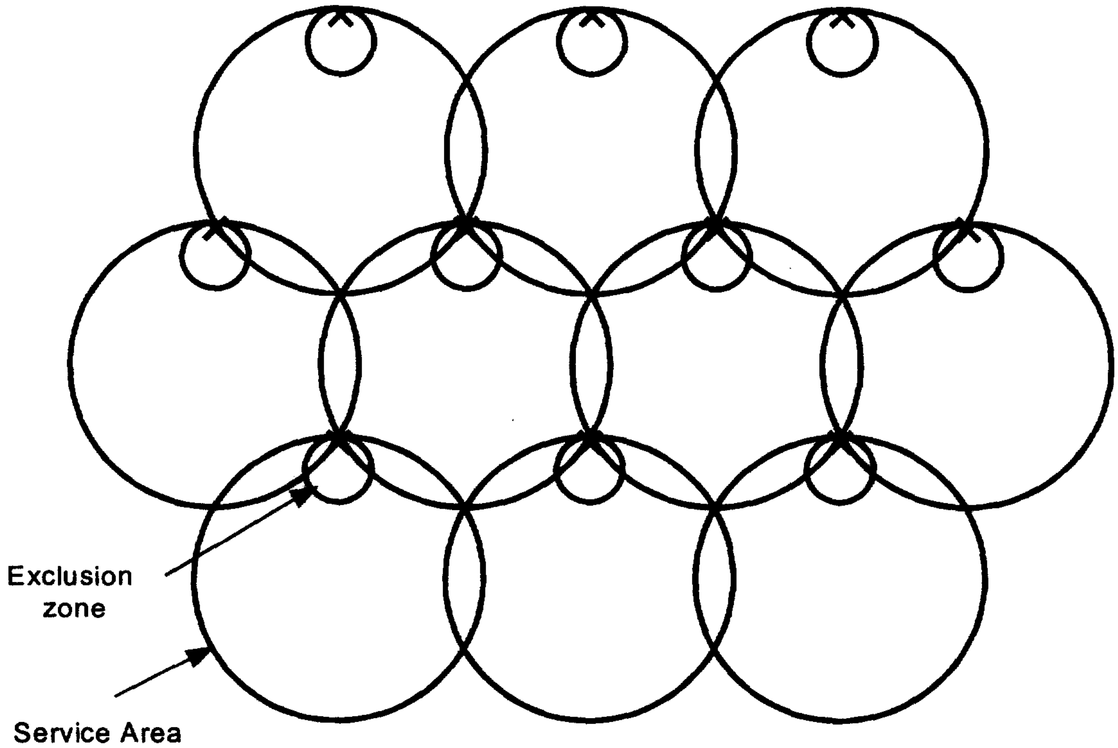

Figure 6: Assumed Gridded Northpoint Service Area

The analysis above assumes essentially ideal conditions. It does not account for interference from multiple Northpoint repeaters, the decrease in service area due to overlap of Northpoint repeaters, possible terrain conditions which would require closer than ideal spacing of the Northpoint repeaters, or increased Northpoint transmitter power to adequately compensate for terrain conditions or population density. All of these factors will increase the area of the NGSO exclusion zone relative to the Northpoint service area.

A similar analysis on the other NGSO FSS applicant systems currently pending before the Commission would probably yield similar results. In such an analysis, Teledesic, Denali, and Virgo would have similar antenna patterns, in that the antenna gain would be essentially flat in the far sidelobes and backlobes. The noise figures for these systems are also likely to be similar to that used by Boeing in the above analysis. Using the same 10% increased unavailability criteria would likely yield similar size exclusion zones for Teledesic, Denali, and Virgo as it does for the Boeing system.

4 Northpoint Link Budget

Boeing has repeatedly expressed concern to the Commission about the impact of rain on the performance of the proposed Northpoint system. The reason for this concern stems from Northpoint's claim that it will normally use a transmit EIRP of -17.5 dBW. Accordingly to Boeing's analysis, use of an EIRP of –17.5 dBW would provide

Northpoint with insufficient margin in the link budget to correct for the detrimental effects of rain.

In order to correct for this link budget deficit – and to provide the same quality and reliability of service as its competitors – Northpoint is likely to regularly increase its transmitted power significantly, thereby greatly increasing unacceptable interference to Boeing's NGSO FSS system and significantly enlarging the exclusion zones around its transmitters. As noted previously, Northpoint's license applications seek authorization to use an EIRP level of 15 dBW. This level is 32.5 dB (or over 1000 times) greater than the "advertised" EIRP value of –17.5 dBW. The explanations that Northpoint has provided for this high power request (Northpoint claims it would be used to transmit over large bodies of water to waterfront communities) seems to lack credibility, strongly indicating that Northpoint plans to use the higher power levels to correct for rain outages.

Northpoint's Technical Annex includes a discussion and a graphical presentation that claims the Northpoint system will be able to accommodate rain attenuation.[12] Unlike some other sections of the Technical Annex, however, there is no indication of the technical basis for these claims, nor is there any description of the analytical methodology that was employed to create the graphical presentation.

Boeing has performed a detailed analysis of Northpoint's rain attenuation problem (*see* Attachment A). It indicates that the information presented in Northpoint's graph is slightly inconsistent (about 1.0 dB) with the Boeing analysis, which was accomplished using methods described in Recommendations of the ITU-R. This inconsistency can be viewed as a minor matter.

A more significant problem is that Northpoint established unrealistically lenient acceptability criteria for its system and then showed they could be met. Specifically, Northpoint gave its system a target availability of 99.7% on an annual basis.[13] A more appropriate target availability should be applied on a "worst month" basis. For example, in the months of June, July and August the East and Gulf coasts of the U.S. are subject to very heavy rainstorms on an almost daily basis. It is for these months that unavailability requirements must be defined. This is comparable to ITU-R processes, which used a "worst month" rain-caused unavailability to establish its BSS system and plan parameters in Appendix 30 of the Radio Regulations.

Attachment A shows that attenuation due to rain within the boundaries of the Northpoint service areas will exceed the margins provided for the Northpoint system during at least 0.3% of the worst month in more than half of CONUS. Northpoint's link budget in its Technical Annex provides a 6.6 dB margin for rain using a 38 dBi gain receiving antenna (about 30 inch diameter).[14] However, as shown in Attachment A and below, the rain

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[12] *See id.* at 7.

[13] *See id.* at 3.

[14] *See id.* at 6.

attenuation that can be expected in the indicated zones (see Figure 7) will exceed this margin for at least 0.3% of the worst months.

Table 3. Northpoint Rain Attenuation from ITU-R Recs. P. 530-7, 837, 838, & 841

Rain Zone	N	M	K
Attenuation at 16 km (dB)	12.33	10.15	7.29

There are several methods available to Northpoint to increase the link rain margin to provide adequate service. However, by far, the least expensive alternative would be to increase the transmitted power. If for installations in rain zone N the EIRP is increased to accommodate the calculated 12.33 dB attenuation, then the exclusion area for Boeing NGSO earth stations would increase by 3.75 times. The interference would be aggravated by the fact that the same rain events would degrade Boeing's signal, making it more susceptible to interference.

Furthermore, Boeing would be unable to mitigate interference resulting from Northpoint's power boosts. While the exclusion zones resulting from Northpoint's advertised transmission level are somewhat predictable, the interference that would result from Northpoint's power increases would interrupt reception by Boeing's customers both inside and outside of Northpoint's exclusion zones.

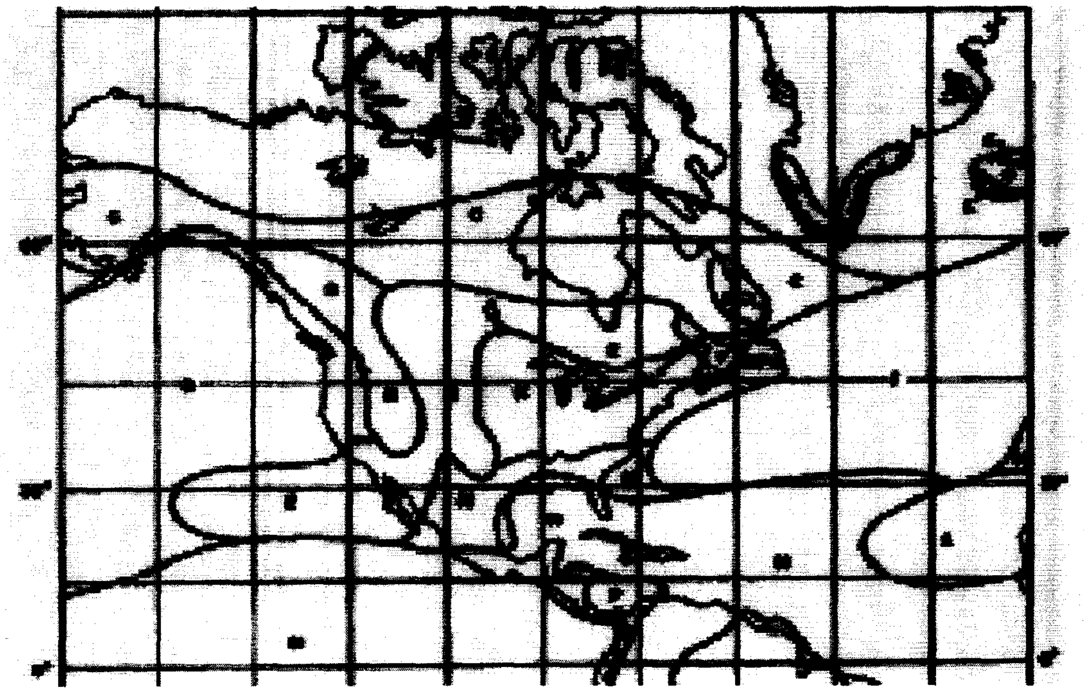

Figure 7: Rain zones for CONUS

In its October, 1999 Progress Report on Northpoint-DBS compatibility tests in Washington, D.C., Northpoint attempts to highlight the fact that Hurricane Floyd passed through the area and Northpoint signals were not lost. While Hurricane Floyd was a significant storm in the Carolinas, the peak rainfall in the Washington, D.C. area was not very high (i.e., 15 mm/hr).[15] Such a weather occurrence would not be deemed to be a significant rain event by the methodology employed in Attachment A. Using the equations from the ITU-R recommendations in Attachment A, the attenuation that would be expected for this rain rate would be 4.0 dB for the Northpoint receiver located furthest (13.27 km) from the transmitter. Since Northpoint claims to have a 2.6 dB rain margin with the antenna used in this test and there is a 1.6 dB path loss advantage (i.e., 13. 27 km vs. 16 km), no loss of signal should have been expected.

5 Interference Mitigation Techniques

Northpoint has proposed a number of interference mitigation techniques that it claims could be used by NGSO FSS earth stations operating inside Northpoint exclusion zones to help avoid the interference caused by the Northpoint system. The following sections discuss the viability of these techniques from the perspective of the Boeing NGSO FSS system.

5.1 Satellite Diversity

Satellite diversity is an interference mitigation technique that NGSO systems must use to minimize the interference into GSO systems and also to minimize the interference to other co-frequency NGSO systems.

As applied to interference mitigation with the Northpoint system, satellite diversity would require the NGSO system earth station receiver to switch from tracking a NGSO satellite when the interference from the Northpoint transmitter exceeds some threshold. The subject earth station receiver would then begin tracking another NGSO satellite in the constellation where the interference from Northpoint is lower than the threshold. This places the entire burden of spectrum sharing with Northpoint on the NGSO system operators.

Satellite diversity cannot be used by Boeing to provide any relief from Northpoint interference. The Boeing earth station operates at a minimum elevation angle of 30 degrees. At off boresight angles of greater than about 33 degrees, the Northpoint interference signal enters the far sidelobe or backlobe of the Boeing antenna. At angles greater than this, the gain of the antenna is essentially flat as shown in the antenna reference pattern of Figure 8 (which is identical to Figure 4). (There is a 5.0 dB increase in the gain from about 80 degrees to 120 degrees, which would increase the level of interference from the Northpoint system.) Interference from a Northpoint transmitter will be in this region of the gain pattern the majority of the time.

The result is that if the Boeing receiver is looking at a Boeing NGSO satellite and the antenna gain toward the interference source (Northpoint) is in the far sidelobe region, switching the earth station antenna to look at a different Boeing NGSO satellite will not change the antenna gain in the direction of the interference source. Northpoint's

[15] *See Northpoint Progress Report*, Figure 1.

interference will still be coming in on the far sidelobe of the Boeing earth station antenna. No matter which way the Boeing earth station antenna is pointed, the interference level from Northpoint will be approximately the same or greater. Consequently, Satellite diversity will not result in any less interference into the Boeing system from the Northpoint transmitter.

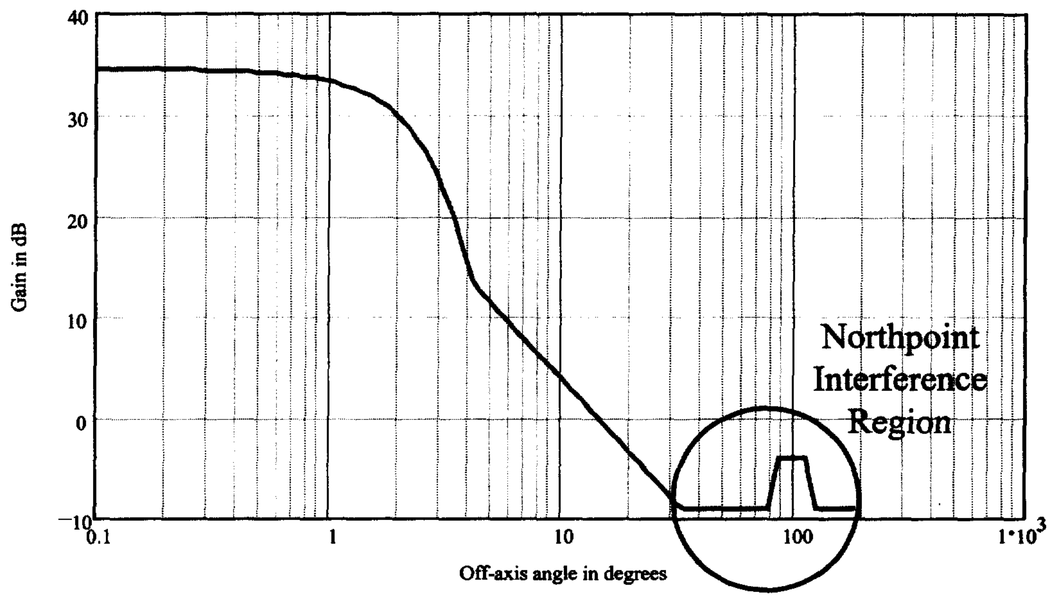

Figure 8: Reference Antenna Pattern

5.2 Shielding

In proposing shielding as an interference mitigation technique to reduce the level of interference from the Northpoint systems to the Boeing NGSO earth station receiver, Northpoint appears to be arguing that the entire burden of providing the shielding should be placed on NGSO FSS operators.

5.2.1 Natural Shielding

The earth station antenna for a NGSO system generally must be able to see in all directions to enable handoff between multiple NGSO satellites going in and out of view. The minimum elevation angle operation for the Boeing NGSO FSS system is 30 degrees. Furthermore, because Boeing shuts down its satellites within a 15° exclusion zone around the GSO arc, consumer receivers in the United States will frequently need to communicate with NGSO satellites located at latitudes north of the receivers' location.

It would be highly unlikely to be able to locate natural shielding (buildings, vegetation, hills, etc.) that would allow good visibility of Boeing's NGSO satellites down to a 30° elevation angle, while still providing shielding from the Northpoint transmitter. Therefore, shielding to mitigate interference from the Northpoint transmitter would require the construction of an artificial shield between the Northpoint transmitter and the Boeing system earth station receiver.

5.2.2 Artificial Shielding

There are two significant components of an artificial shield. The first is the amount of attenuation required of the shield, and the second is the size of the shield that is required.

The amount of attenuation required is simply the reduction in interference level that is required to meet the interference criteria at a given distance from the Northpoint transmit antenna. Figure 9 shows the additional attenuation required to meet the interference required for a Northpoint transmitter operating at a nominal EIRP of –17.5 dBW and operating at the maximum EIRP of +15 dBW.

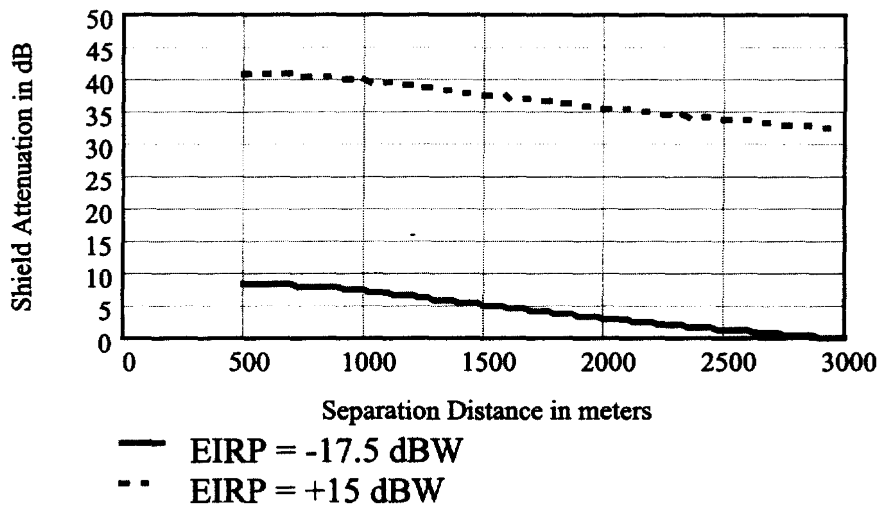

Figure 9: Shield Attenuation Required

The size of an artificial shield wall required to shield a Boeing earth station antenna from a Northpoint transmitter is dependent on the distance the Boeing receiver is from the Northpoint transmitter and the height of the transmitter. Another significant factor to determining the height of the shield is the distance between the shield and the receive antenna. One approach to determining the shield wall distance from the antenna is based solely on geometric consideration of how close the shield can be to the antenna. Figure 10 provides an illustration of the geometry that is considered. The antenna being shown is a 60 cm parabolic reflector antenna, and is depicted as a flat plate mounted 0.5 meters above the surface. This is equivalent to the Boeing IDS antenna. The BDS antenna is a 1.2 meter diameter antenna. The antenna is directed at a minimum elevation angle of 30 degrees, and has the first null in the antenna pattern at an angle of about 3 degrees. A line is drawn from the top edge of the antenna to the Northpoint transmit antenna. A second line is drawn from the bottom edge of the antenna along the angle of the first null of the Boeing antenna. The distance where the two lines cross is the location of the shield wall relative to the antenna. Figure 11 shows the distance and height of the shield from the IDS antenna as a function of the distance from the Northpoint transmit antenna. Figure 12 shows the height and distance for the larger BDS antenna.

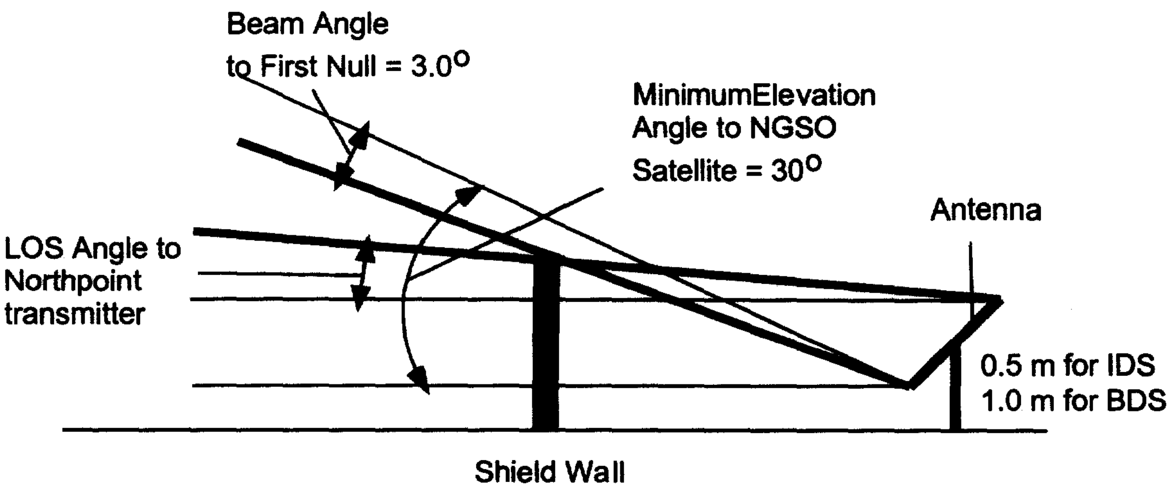

Figure 10: Shield Geometry

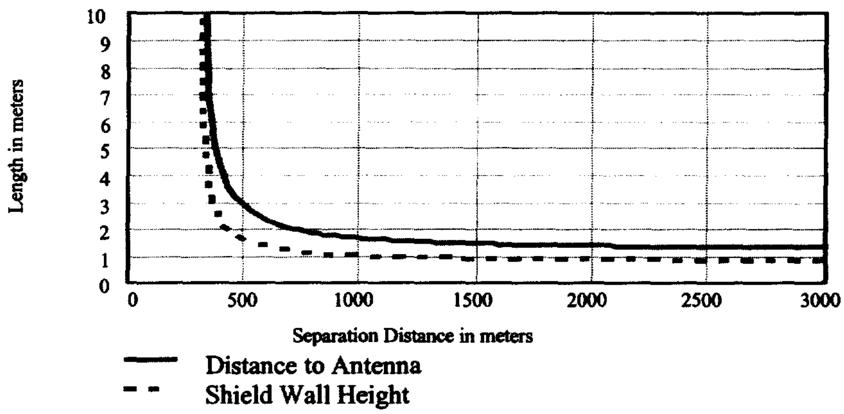

Figure 11: Distance and Height of the Shield from the Boeing IDS Antenna

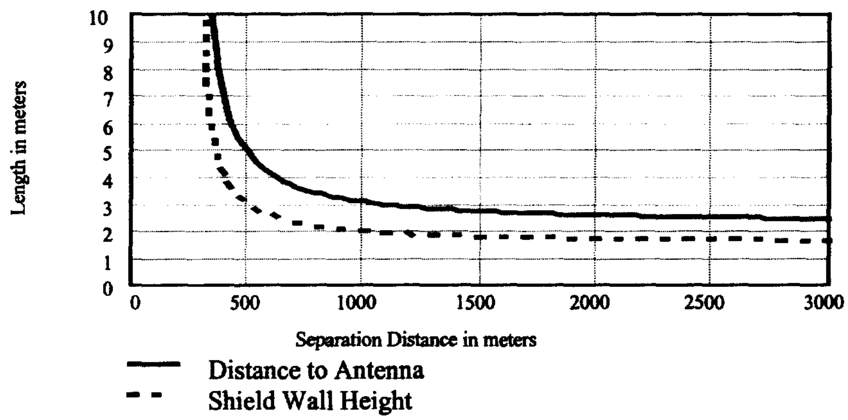

Figure 12: Distance and Height of Shield from Boeing BDS Antenna

In both cases, the shields are well within the near field regions of the antennas and some distortion of the sidelobe pattern will occur. The near-field region distance of the IDS antenna is 15 meters, and the near-field region distance of the BDS antenna is 60 meters. Scattering from the shield wall in a region so close to the antenna would increase the effective sidelobes of the antenna making it more susceptible to interference from the Northpoint transmit antenna. Since the Boeing earth station is a bi-directional unit (transmit as well as receive), the scattering of the shield wall will also increase the transmit sidelobes resulting to increased interference to other co-frequency users of the transmit spectrum. The shield will have to be at a greater distance than indicated above, which will also increase its height.

A second method was also used to determine the shield distance and height. This was to place the shield wall at the edge of the near field distance from the antenna and then compute the height of the shield required. Figure 13 shows the results of that calculation for both the IDS and BDS antennas.

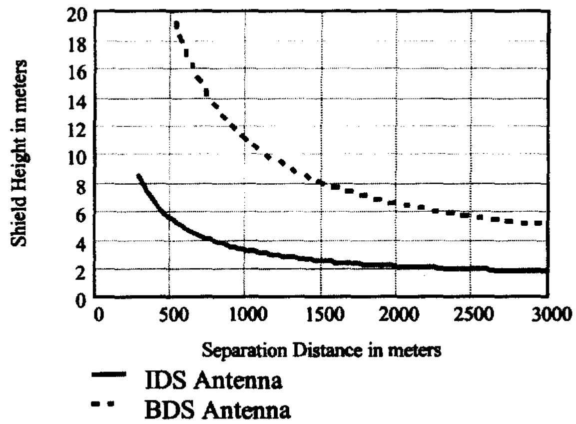

Figure 13: Shield Height for IDS and BDS Antennas at the Near Field Distance

In this case, the shield would have to be at a greater distance from the antenna than indicated by the geometric analysis alone due to the near field distortion of the antenna pattern. However it would probably not have to be at a distance as great as the near field distance. A possible answer lies somewhere in between the values found in these two methods. Nevertheless, while some form of shielding might provide interference mitigation near the edge of the exclusion zone, shielding within about 1 km of the Northpoint transmitter becomes physically impractical.

5.3 Satellite Diversity and Natural Shielding

Another option proposed by Northpoint was to place the Boeing earth station antenna behind some natural obstruction, such as the south side of a building. This would shield it from the Northpoint transmitter, and then satellite diversity could be used to connect to Boeing NGSO satellites that are generally south of the Boeing earth station. Boeing does not plan to operate its NGSO system with beams from multiple satellites covering the same area. To do so would significantly increase the Boeing system interference into GSO receivers and possibly violate the internationally agreed upon interference limits for NGSO systems.

The beams from the Boeing NGSO system have a large coverage area, approximately 1800 km in diameter. To provide coverage to Boeing earth stations within the Northpoint exclusion zone would require that all Boeing coverage be from the south. Such a requirement would increase the number of satellites that Boeing would need in its constellation and also increase Boeing interference into GSO receivers, possibly in violation of proposed ITU-R interference limits for NGSO systems.

Additionally, in the case of Teledesic, such a solution would not work at all, as the Teledesic scheme for interference mitigation with the GSO satellites is to have its earth stations always look to the North. If there was shielding available to the north to block interference from Northpoint, that obstruction would also shield the Teledesic earth station antenna from connecting to the Teledesic satellite.

The Boeing operating plan is to provide service to an area with a beam from the highest elevation angle satellite. When that satellite is in an interference condition with either a GSO satellite or co-frequency NGSO satellite, the beam would be switched off and traffic routed through another Boeing NGSO satellite that does not have an interference condition. Since all the satellite orbits are known in advance, it is possible to predict ahead of time when these interference conditions will occur and plan the switch.

5.4 Frequency Diversity

Northpoint has proposed another interference mitigation scheme of "frequency diversity" for spectrum sharing with the NGSO systems. Again, this scheme places the entire sharing burden on the NGSO FSS systems. The impact of this sharing scheme would be to reduce the system capacity available to NGSO FSS users in the exclusion zone by a factor of two.

Under Northpoint's proposal, NGSO FSS networks would be barred from using Northpoint's desired spectrum (the 12.2-12.7 GHz band) to serve consumers within the exclusion zone around each Northpoint transmitter.[16] Instead, NGSO FSS networks would be limited to the 11.7-12.2 GHz band within the exclusion zones and would be able to use the entire 11.7-12.7 GHz band outside the exclusion zones.

The Commission's NPRM proposes that the frequency band from 10.7 to 11.7 GHz be used by NGSO systems for feeder links only and the frequency band from 11.7 to 12.7 GHz be used for service links. If Northpoint uses the band 12.2 to 12.7 GHz, the spectrum available for use in the exclusion zone is reduced by a factor of two. As many of the potential customers that will use the Boeing NGSO systems are in the metropolitan areas that Northpoint also plans to serve, this will have a direct impact on the economic viability of the Boeing NGSO system.

As discussed in a previous section, Boeing's MEO satellites will operate with beams about 1800 kilometers in diameter – far too large to differentiate between customers

[16] *See Northpoint Technical Annex* at 13.

inside and outside Northpoint exclusion zones. Each satellite beam will include two 166.6 MHz channels, which will be used on a shared basis by all customers using a code division multiple access ("CDMA") scheme. As a result, customers will be unable to use discrete band segments to avoid interference from Northpoint.

Northpoint also suggests that Boeing segregate the two 166.6 MHz channels in each satellite beam, operating one channel in the 11.7-12.2 GHz band, where Northpoint will not produce interference, and operating the other channel within the 12.2-12.7 GHz band, co-frequency with Northpoint.[17] Northpoint argues that Boeing could use the lower channel to serve customers inside the exclusion zones and use both channels to serve customers outside the exclusion zones.

Northpoint's proposal might seem appropriate for a satellite system designed to carry traditional point-to-point telephone services, where each call originates at one point and terminates at another discrete location. Unfortunately, very few of Boeing's customers are expected to use Boeing's satellite system solely in this manner. Instead, most transmissions will involve point-to-multipoint communications – such as a corporation or government agency transmitting the same information to numerous recipients, or a Internet service provider using smart push technologies to continually update an Internet page being viewed simultaneously by thousands of customers.

Because of the point-to-multipoint nature of Boeing's services, any spectrum mitigation technique that forces Boeing to isolate many of its consumer receivers to a single 166.6 MHz channel would significant reduce the effective capacity of Boeing's system. Boeing would be forced to accommodate all point-to-multipoint communications in the lower 166.6 MHz channel assignment to ensure that intended recipients inside Northpoint exclusion zones successfully receive transmissions. Since the vast majority of Boeing's services will be point-to-multipoint in nature, Boeing's network would be left with inadequate spectrum capacity that is unencumbered by Northpoint interference, compromising the financial viability of Boeing's global network.

6 NGSO Interference into Northpoint

As discussed previously, Northpoint proposes a significantly different interference criteria when considering NGSO interference into Northpoint as compared to Northpoint interference into NGSO systems. Table 4 gives the interference criteria that Northpoint indicates is appropriate for assessing interference into its system and Table 5 gives the interference criteria that Northpoint indicates is appropriate for assessing interference its system causes to NGSO receivers.

[17] *See* Letter to Donald Abelson, Chief, International Bureau, from Antoinette Cook Bush, Counsel for Northpoint Technology, Ltd., at 2 n.3 (Jan. 20, 2000) ("*January 20th Letter*").

Table 4: Northpoint Proposed Interference Criteria for NGSO FSS Receivers[18]

I/N Level	Percent of Time
0 dB	0.01
-12.2	20

Table 5: Northpoint Proposed Interference Criteria for Northpoint Receivers[19]

I/N Level	Percent of Time
0 dB	0.001
-13	20

For the short time criteria, Northpoint wants the NGSO systems to accept a higher level of interference from Northpoint for a percentage of time 10 times greater than the interference it is willing to accept from NGSO systems. For the long time criteria, Northpoint wants the NGSO systems to accept an interference level that is also higher than it is willing to accept. Northpoint wants more interference protection for its service than it is willing to provide for other services, clearly an unreasonable standard for a newly proposed co-frequency service.

With substantial participation by the United States government, the ITU-R has been working the past three years to develop interference criteria and limits to be applied to NGSO FSS systems sharing spectrum with terrestrial systems. The U.S. terrestrial service providers have been heavily involved in these discussions and an agreement was been reached, which the U.S. government endorsed, that covers services in the 11.7 to 12.75 GHz band. Boeing strongly supports that agreement and feels that these sharing criteria and limits should be adopted by the Commission.

In its analysis of interference from NGSO systems into Northpoint receivers, Northpoint seems to be ignoring some fundamental laws of physics. Northpoint claims that Boeing will not cause unacceptable interference into Northpoint's system because Boeing's constellation will not operate at elevation angles below 30 degrees. While it is true that the Boeing system will not operate at elevation angles less than 30 degrees, the Boeing transmit beam is not truncated at 30 degrees elevation angle. Instead, the beam has a smooth continuous shape and therefore will produce some energy at elevation angles below even 5 degrees. To require Boeing to reduce the PFD at elevation angles below 5 degrees would require reducing the transmit power of the beam, which would reduce the data capacity of the beam.

Despite this fact, Boeing agrees with the Northpoint assessment that the Boeing system will not cause interference into the Northpoint system. As indicated in Figure 1, the Boeing NGSO FSS system has a minimum elevation angle of 42 degrees to an earth

[18] *See Northpoint Technical Annex* at 31.

[19] *See id.* at 20.

station looking north from a latitude of 20 degrees. As a result, a Boeing NGSO satellite will not have transmit energy near the main beam of a Northpoint receive antenna and will not cause unacceptable interference to the Northpoint receivers. Nevertheless, as indicated in Boeing's FCC application, the Boeing system will exceed a PFD of –158 dBW/m2-4kHz at elevation angles below 2 degrees. Therefore, Northpoint's proposal to reduce the allowable PFD at elevation angles below 5 degrees is excessively constraining on the NGSO system operators while not providing any benefit to Northpoint.

Northpoint has not documented all of the conditions it assumed in the dynamic analysis of the interference from the Skybridge NGSO system to its receivers and therefore, it is difficult to determine the validity of this analysis. However, it appears to be a very worst case analysis. For example, the analysis assumes that the low elevation angle beams of a Skybridge NGSO satellite are always on. In contrast, Northpoint acknowledges that the nominal beam assignment strategy that Skybridge and Boeing both plan to use is to use the beams from the satellite with the highest elevation angle available. Such a beam assignment strategy would indicate that the low elevation beams are only used infrequently. The result is that Northpoint has significantly overestimated the percentage of time a given level of interference would be present at its receive antenna coming from SkyBridge's NGSO network.

7 Summary:

The interference criteria used by Northpoint was inappropriate. The appropriate interference criteria should be that defined in ITU-R Recommendation S.1323. This allows the aggregate of all interfering sources to increase the link unavailability of a co-frequency system by no more than 10%. When this criteria is used with the Boeing NGSO FSS satellite system, interference from the Northpoint transmitter at a nominal EIRP of –17.5 dBW will produce an exclusion zone of about 3 km in diameter where Boeing earth station receivers will have unacceptable interference. Should the Northpoint transmit EIRP be increased to the maximum power Northpoint has requested, +15 dBW, the exclusion zone becomes 129 km in diameter.

Boeing is also concerned about Northpoint's treatment of rain attenuation in its link budget. Properly accounting for rain outages will require Northpoint to use a higher transmit power or increase the number and density of its transmitters. This would further enlarge the exclusion zone where Boeing earth station receivers would be subjected to unacceptable interference. In its analysis, Northpoint has also failed to account for terrain conditions. Accounting for terrain will require the Northpoint system to transmit at higher power levels or increase the number and density of transmitters. All of these conditions will increase the relative size of the Northpoint exclusion zones.

Northpoint has proposed some interference mitigation schemes, almost all of which place the entire burden for interference mitigation on Boeing and the other NGSO FSS systems. Some of these schemes, such as using satellite diversity to avoid interference from Northpoint, simply will not work. Others, such as providing shielding for the Boeing earth station receive antenna, result in significant added cost to the earth station and will ultimately result in loss of customers in the exclusion zone areas.

Northpoint also wants more stringent interference protection from NGSO FSS systems than it is willing to provide to NGSO FSS systems. Significant work has been done by ITU working groups in determining a fair and adequate interference criteria and limits on NGSO interference into terrestrial services. Boeing strongly supports the agreements reached in the ITU working groups and feels that these should be adopted by the Commission.

ATTACHMENT A

Calculations and Methodology for Computation of Rain Fades in the Northpoint System

The computation of rain fades in the Northpoint system has been accomplished using a number of ITU-R Recommendations. Specifically:

ITU-R Rec. P. 530-7	Propagation Data and Prediction Methods Required for the Design of Terrestrial Line-of-Sight Systems
ITU-R Rec. 837	Characteristics of Precipitation for Propagation Modeling
ITU-R Rec. 838	Specific Attenuation Model for Rain for Use in Prediction Methods
ITU-R Rec. 841	Conversion of Annual Statistics to Worst-Month Statistics

The analysis starts with the basic path attention equation:

$A_{.01} = \gamma \, d \; r$ (eqn. 37 of Rec. P. 530-7)

where: $A_{.01}$ is the path attenuation exceeded for 0.01% of the time

d is the path length in km.

$\gamma = k R^{\alpha}$ (eqn. 1 of Rec. 838)

k and α are frequency dependant coefficients in Table 1 of Rec. 838, which are .0213 and 1.2075 respectively for 12.5 GHz; R is the rain rate exceeded 0.01% of the time in the specific rain zone.

$$r = \frac{1}{1 + (16/do)}$$ (eqn. 35 of Rec. P. 530-7)

where: $do = 35e^{-0.015R.01}$ (eqn. 36 of Rec. P. 530-7)

From Rec. 837 the rain rates exceeding 0.01% of the time for zones K, M and N (see Figure 1 attached), which constitute more than half of CONUS and all of Puerto Rico, are:

Zone		mm/hr
N	=	95
M	=	63
K	=	42

The interim results of the calculations are:

Rain Zone	Rain Rate	r	γ (dB/Km)	d(Km)	$A_{.01}$(dB)
N	95	.34	5.21	16	28.34
M	63	.46	3.17	16	23.33
K	42	.54	1.94	16	16.76

The next step is to convert the attenuation exceeded for 0.01% of the time annually to 0.3% for the worst month. Attenuation exceeded for other percentages of time (p) may be calculated using the following power law:

$$\frac{A_p}{A_{.01}} = 0.12\, p^{-(0.546 + 0.043 \log p)} \qquad \text{(eqn. 38 of Rec. P. 530-7)}$$

To convert worst month statistics (pw) to annual statistics (p):

$$p = 0.30\, pw^{1.15} \qquad \text{(eqn. 5 of Rec. 841)}$$

Where: pw is the worst month %

Thus the final calculations show the attenuation over a 16 km path that would be exceeded for 0.3% of the worst month are:

Rain Zone	$A_{.01}$ (dB)	Pann% for p_w = .3%	conv. factor	Ap_w (dB)
N	28.34	0.075	.435	12.33
M	23.33	0.075	.435	10.15
K	16.76	0.075	.435	7.29

CERTIFICATION OF PERSON RESPONSIBLE FOR PREPARING THE ENGINEERING INFORMATION INCLUDED IN THE BOEING COMPANY ANALYSIS OF INTERFERENCE CHARACTERISTICS OF NORTHPOINT TECHNOLOGY, LTD.

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in the Analysis of Interference Characteristics of Northpoint Technology, Ltd. I certify that I have either prepared or reviewed the information submitted in this petition, and that it is complete and accurate to the best of my knowledge.

By: Robert P. Higgins
Robert P. Higgins
The Boeing Company

Feb. 16, 2000